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High Altitude Survey Balloons

Sea-Space Systes, Inc.

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Abstract

Sea-Space Systems has developed a small balloon which can achieve altitudes up to 150,000 ft, carrying survey instrument payloads. This balloon utilizes the Corporation's new balloon fabric -- MERFAB. Because of its very light weight and high strength, MERFAB allows the construction of balloons with extreme altitude performance and cold temperature accommodation. Operational objectives of this survey balloon include launching ease along with reasonable cost and good reliability. The new concept in launching is directed towards one man operation in elevated winds. Recent flight experiences with the balloon and unique launching technique have indicated very satisfactory results.

1. INTRODUCTION

The development of MERFAB, a new light balloon fabric, is involved primarily with the desire to go to altitudes of 150,000 feet and above. This desire stems from the fact that conventional balloon practice appears to have an asymptote ceiling at 150,000 feet. This is a barrier which SSS would hope to raise. In order to do this, it is necessary to achieve a considerably lighter fabric than is generally available, the latter being associated with Mylar, polypropylene, polyethylene and some of the more recent scrim types. Three years ago, it was the conclusion that, in order to go towards lighter fabrics, a thinner film was required; and, that going to thinner films it would be found they were necessarily rather weak and would not handle the loads that would be experienced in a flight from launch thru the tropopause to altitudes of 150,000 feet. As a consequence the films would have to be reinforced to some degree. Thus, it was necessary to create a very thin film which would take the gas pressure and then by the use of reinforcing mesh, the strength requirements could be met.

The films used for MERFAB in SSS' current efforts are directed primarily towards the utilization of a 1/4 mil thickness made from a polyethylene derivative. Strength members are nylon bonded to the polyethylene in a number of different grid patterns depending upon the particular strength requirements of the

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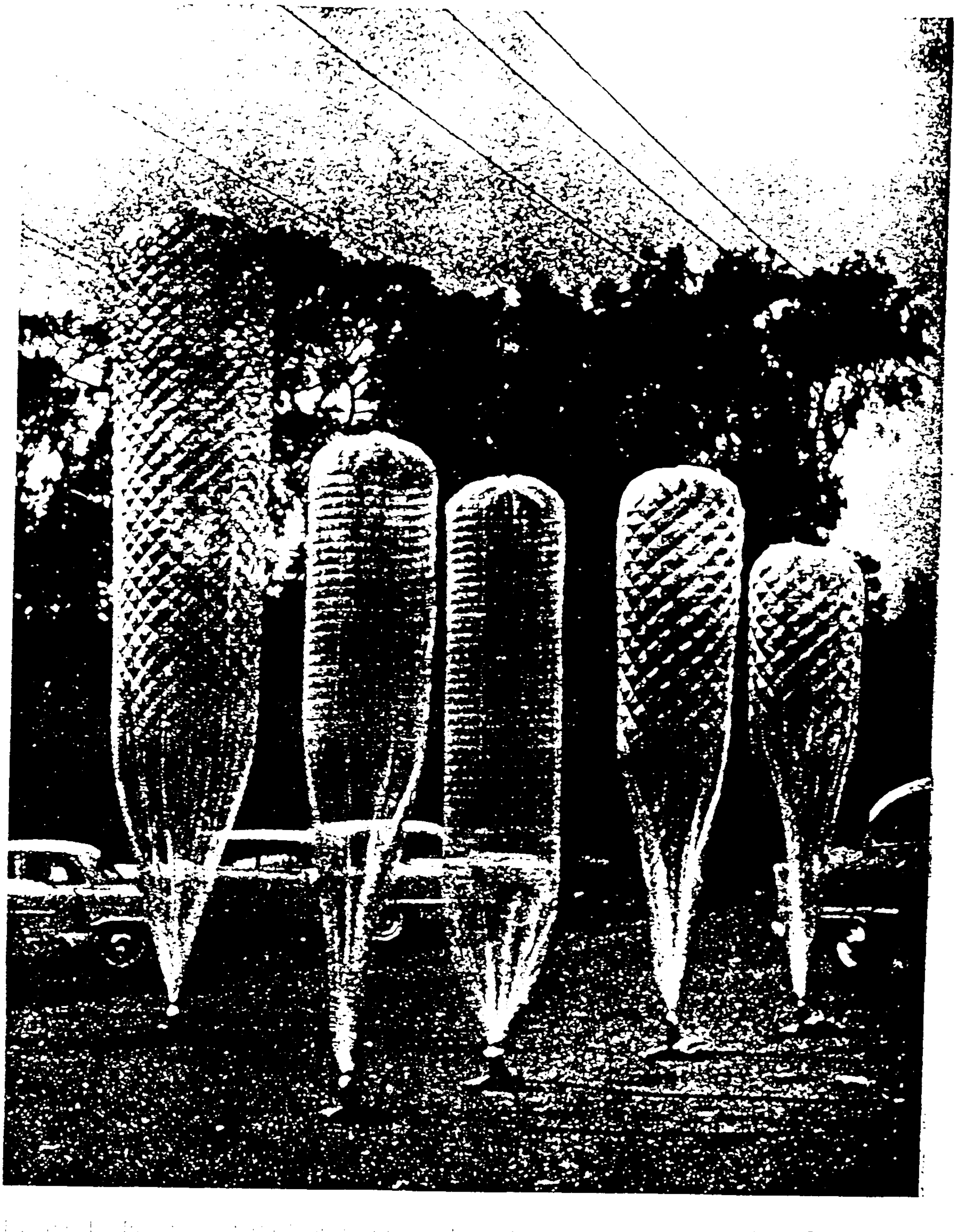
system. The test units in Figure 1 embody several different approaches to grid patterns. Some initial problems were encountered with delamination at altitude environmental temperatures of minus 90 degrees F; handling temperatures in the regime of minus 110 degrees F are now easily satisfied. A second aspect, that of fabricating an operational balloon of this very light material, involves the problem of quality control. It was found that the conventional techniques for quality control do not apply because the material is relatively fragile; thus, the handling processes require special attention and seaming techniques are unique. These factors have received developmental effort over the past two years with a resulting low weight high strength fabric and a compatible processing technique.

It is interesting to note that, originally when SSS first started making the very light fabrics, it was done by hand on a loom with weavers passing the shuttle back and forth; this, of course, was a very laborious process. About the time a crew of Navajo Indian rug weavers was engaged, Mr. Tom Kelly said we were violating the child labor laws, and it would have to be done a different way. Consequently, during the summer of 1963, SSS completed the development of a prototype fabrication machine to effect the weaving automatically. The machine not only weaves, but it also laminates and cures in one continuous process.

Now, turning to the potential of this fabric, the drive to date has been directed primarily toward very high altitude flights. If lower flight altitudes are desired -- say 100,000 feet or less -- and the job can be done with a polyethylene or neoprene type balloon, MERFAB does not appear to have application; however, if altitudes in excess of 100,000 feet are required and in particular altitudes of 150,000 feet, then MERFAB is strongly indicated. For future reference in the case of superpressure balloons and/or load carriers, it appears that the material has excellent potential.

As a first step in using MERFAB for an operational application it was felt that a modest case should be attempted involving a sounding balloon which would carry a small payload to an altitude of 150,000 feet. This useage means generating the capability of built-in gas containment with a large expansion ratio. By way of visualization, if one starts with a cubic foot of lifting gas at sea level, it will expand to well over 350 cubic feet by the time it gets to the altitudes of interest; MERFAB can represent this type of volumetric change capacity.

Now for this first step, what are the specifics that would be desirable? Certainly, there are a number of scientists and military personnel who would be interested in carrying scientific payloads to 150,000 feet. As a consequence, it was determined that a reasonably small scientific payload to that altitude would be commensurate with a radiosonde. Thus a design point of 150,000 feet with a 3.5 pound payload was chosen. Certainly, weather considerations were paramount including the accommodation of temperatures in the equitorial regions to minus 90 degrees F; the latter



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create major problems for neoprene type balloons. In order to stand strong wind shears in transit of the tropopause the design should have a large degree of structural capacity. Lastly, there was a strong desire to create a balloon that had launching ease for the untrained user.

In reference to previous balloon history, it is a well established fact that balloon launching is quite a problem. Thus, one of the major objectives was to provide a balloon that a scientist could take in the back of his truck or station wagon, quickly set it up and launch by pulling a lever. His efforts, then would not be expended on the support train for the balloon or launching equipment but rather he could concern himself primarily with the scientific experiment. Thus, the design must generate a launching technique that can accommodate a reasonable amount of wind, has a flexible mobile launching capability, and can be launched by one man if necessary.

The design point of 150,000 feet and a 3.5 pound payload is shown on the performance graph, Figure 2. The curve gives the general operational effectiveness of the MER-H-3 design. If the balloon performance capability is examined, it is seen that a 12 pound payload can be lofted to 140,000 feet.

MER-H-3 Balloon specifications are presented in Figure 3. The size of the sea level bubble is 10 feet in diameter with the top 9.5 feet above the ground. Considering that there is probably quite a long line associated with the payload in order to remove it from the air stream perturbations caused by the balloon, a launch train of approximately 200 feet results. It should be noted that this is a fairly lengthy train for a one man launch. The balloon at 150,000 feet will have a 79 foot diameter. At launch it requires 534 cubic feet of lifting gas.

In operational launches, it has been demonstrated that one man can prepare and fill the balloon in approximately 30 minutes; launching is effected by a lever release. The latter, in addition to creating one man feasibility, is extremely effective in situations where the launch has to be coordinated with another operation with release on the zero countdown. For some cases a reasonable amount of acceleration control has been included to limit the high "g" dynamic launch loads.

In terms of the balloon launching hardware, Figure 4 represents a complete system including a radiosonde payload and associated parachute. The balloon is packed in a box, which sits in a foldable launcher. The gas requirement can be effected with three standard bottles. Figure 5 shows the launcher set up for operation and the balloon protective covering folded out. Attention must be given to the protection of the balloon material because it cannot be handled in the conventional manner. It is relatively fragile and if pulled with the fingers, stress concentrations can result with the possibility of gas leakage. Thus, the protective system is designed to prevent the user from actually grasping the balloon itself with his hand.

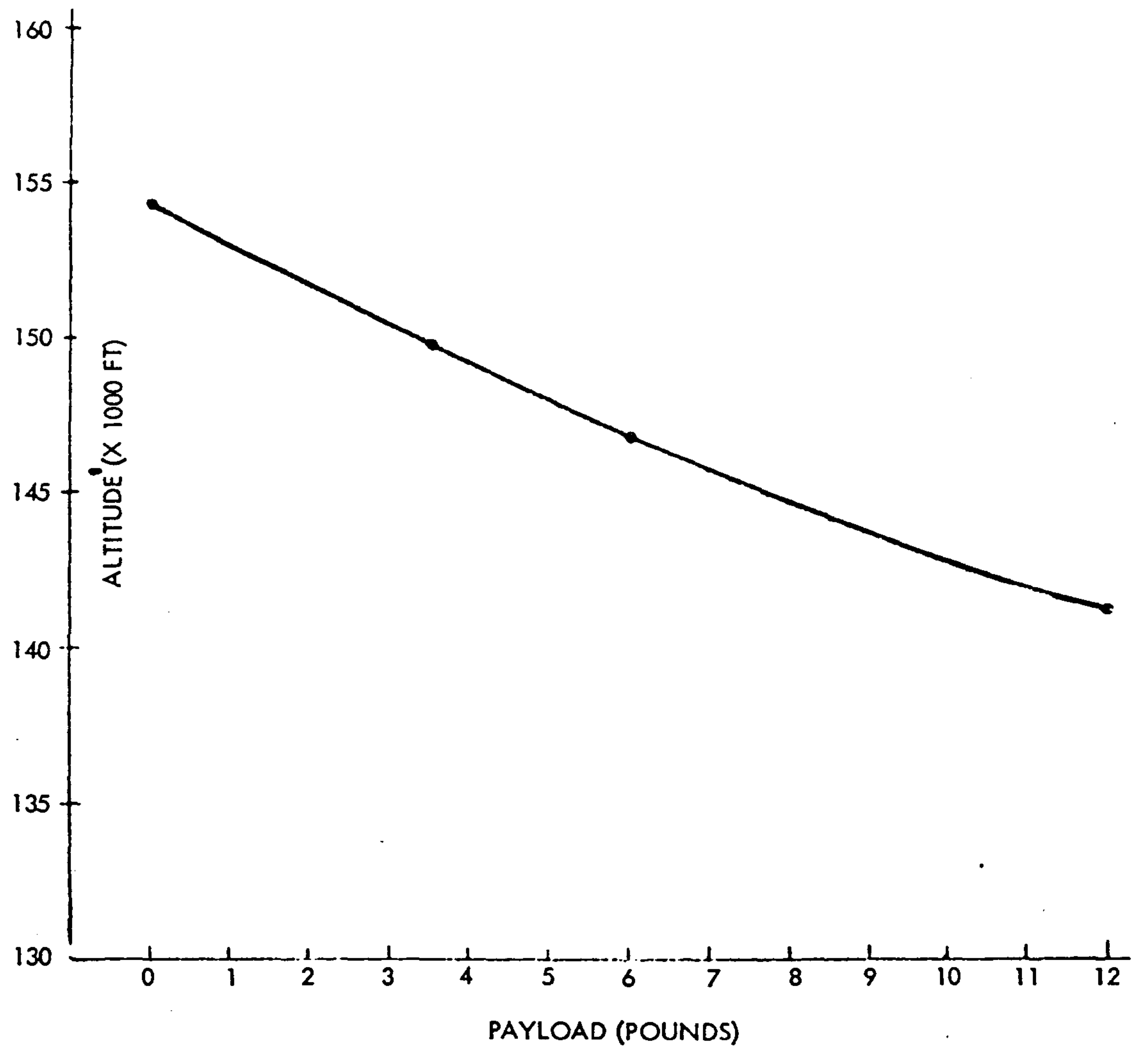


Figure 2. Payload vs Altitude for MER-H-3 Design

The balloon is contained in its transportation box with the balloon never emerging from the box until the actual launch. The section that is inflated for the initial bubble fill is protected by an outside sheath covering which comes off after launch.

In Figure 6 the bubble is fully inflated, ready for launch. It should be noticed that the launcher has two arms to the front, and one arm to the rear. This configuration allows orientation of the twin arms into the wind in such a way as to resist the wind forces. There is a tab arrangement to hold the bubble secure and shield the balloon from wind gusts. The taut bubble installation can sit in a reasonable amount of wind, then, with a man to the rear holding the payload in one hand, the

PERFORMANCE:	3.5 LBS TO		150000 FT
SIZE:	S.L. BUBBLE	-	10 FT DIA. 9-1/2 FT GND. TO TOP
	S.L. TRAIN	-	200 FT w - P.L.
	150 K ALT	-	79 FT DIA.
FILL REQ.	H_E GAS @ S.L.	-	534 FT^3 STP
LAUNCH	ONE MAN PREP.	-	30 MIN.
		-	LEVER RELEASE
		-	"G" CONTROL

Figure 3. MER-H-3 Balloon Characteristics

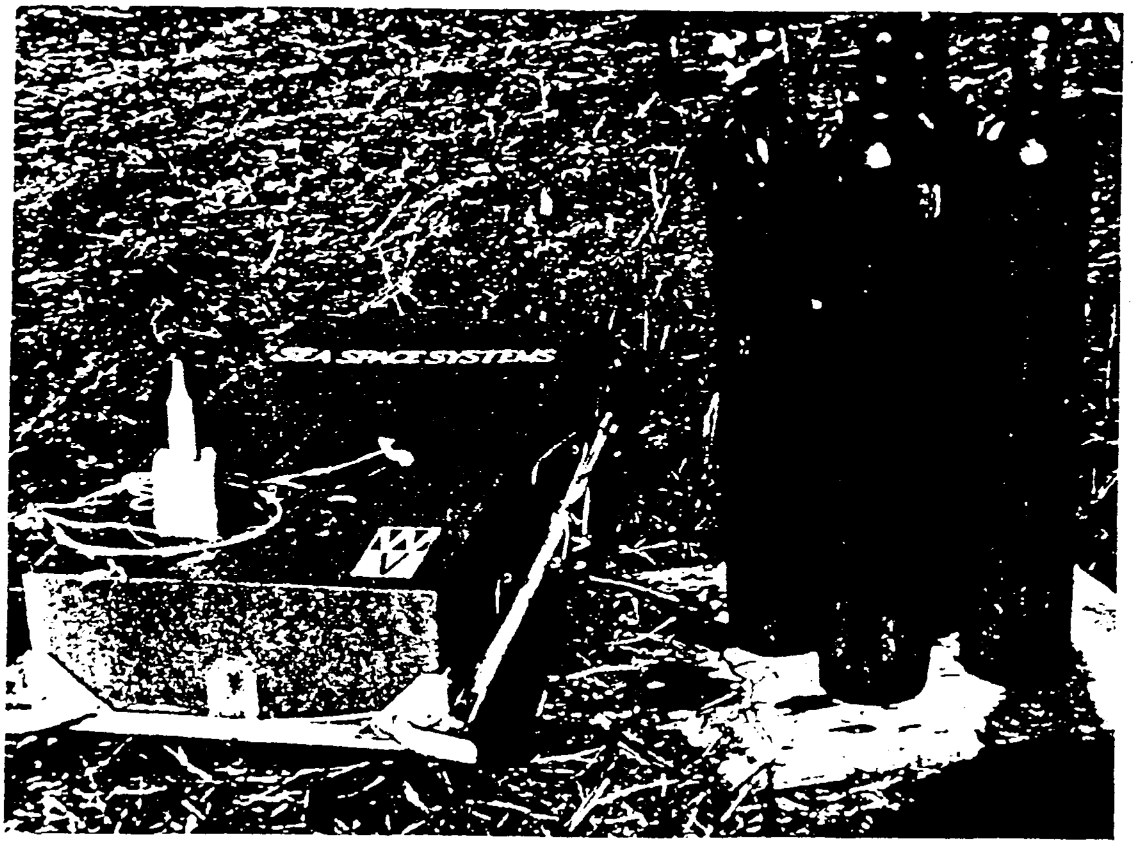


Figure 4. Complete MER-H-3 System, Including Radiosonde Payload and Associated Parachute

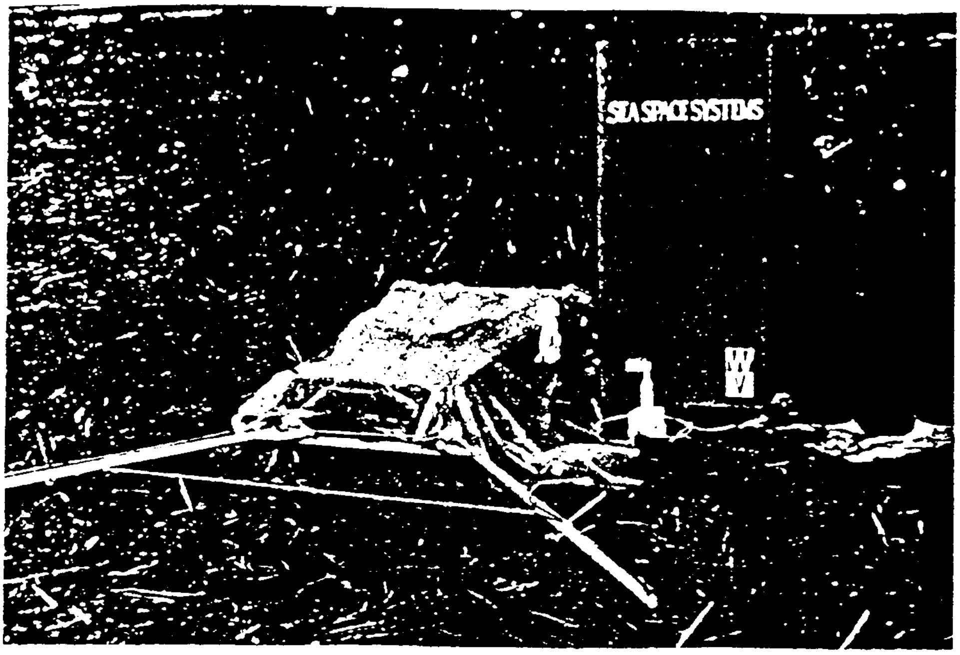


Figure 5. Launcher Set Up for Operation with the Balloon Protective Covering Folded Out

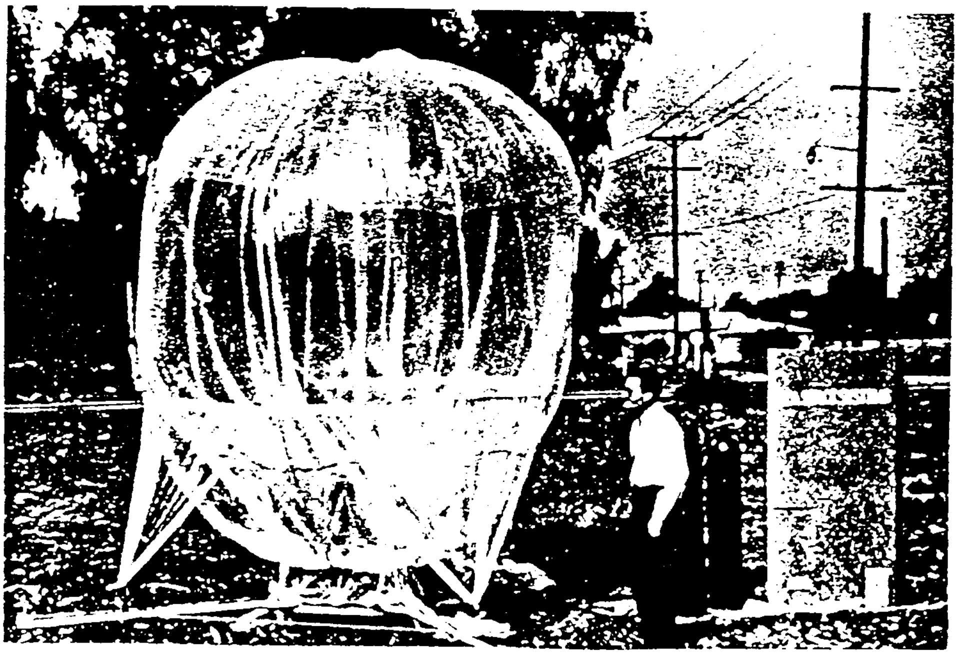


Figure 6. Bubble Fully Inflated, Ready for Launch

Figure 7. MER-H-3 an Instant after Release

balloon can be launched by pulling the release lever with the other. Launchings to date have been highly successful. The maximum condition experienced in the lee of an inflation building has been in a wind of 20 knots with gusts to 28; this represents a high capacity to accommodate wind.

It is felt that the launch capability described above can go to even larger bubbles associated with 2 million cubic feet balloons while still maintaining the system portability. Several launches are scheduled with 1.5 million cubic feet balloons carrying 25 pound payloads using this same launch equipment.

Figure 7 shows the MER-H-3 balloon just an instant after release. It is seen that the protective sheath has now cleared the launcher; it will be released after the balloon has ascended further. Additional protection of the fabric during ascent trajectory is achieved by a system of reefing which is removed progressively as the

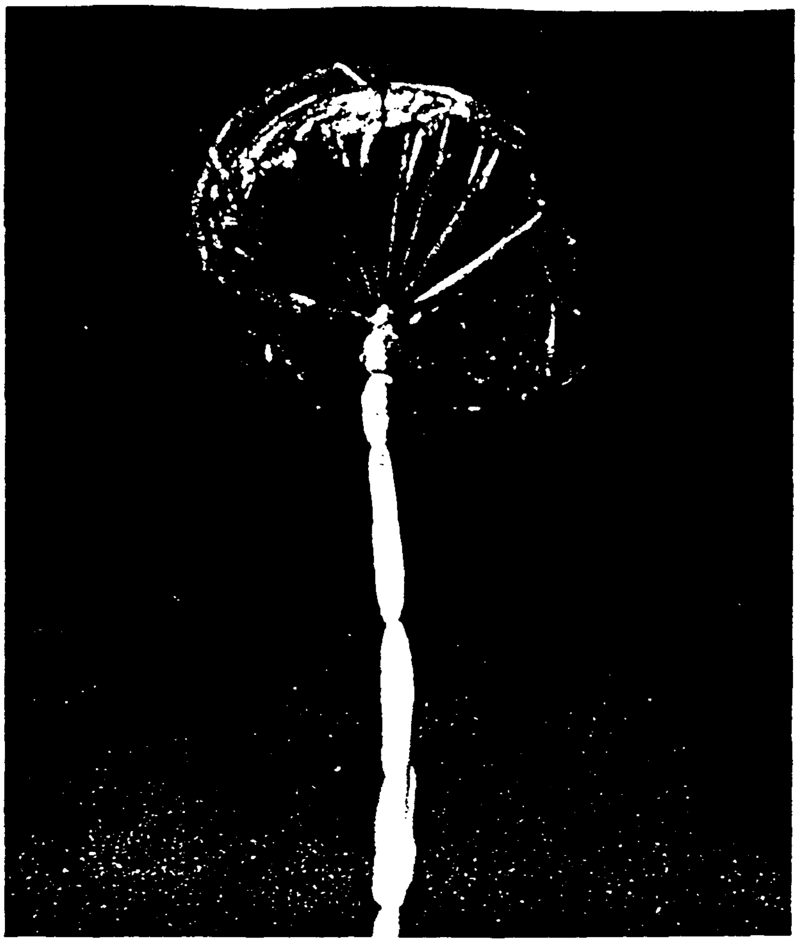


Figure 8. MER-H-3 Ascending

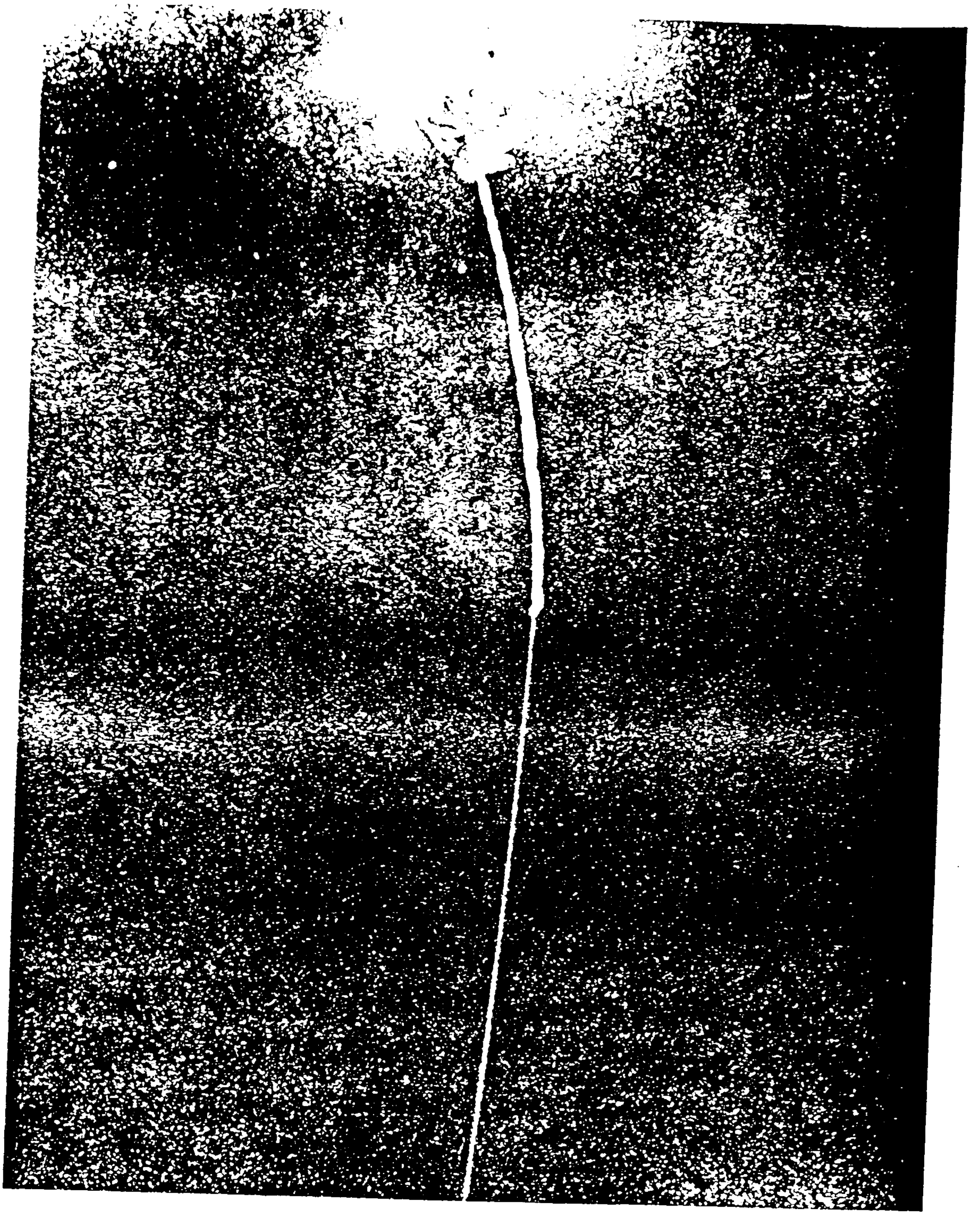
balloon goes to altitude. The next two figures successively picture the bubble and launch train as the balloon clears the ground; the long length of the train is clearly visible.

Flight progress to date can be summarized for a unit whose performance altitude was 146,000 feet in the following AEC press release:

"Near record altitudes for unmanned balloons were reached in test flights at Tonopah (Nev.) Test Range when one reached an altitude of 145,000 feet (about 27 miles) on October 4.

"The previous National Aeronautics and Space Administration record of 148,000 feet was set by a U.S. Navy Skyhook balloon on September 4, 1959.

"Designed to carry radiosonde weather observing equipment, the balloons were tracked by radar to give wind observations and altitudes with about 50-foot accuracy.



"Weather data at these altitudes are used in studies of world-wide stratospheric fallout.

"The balloons were designed and manufactured by Sea-Space Systems, Inc., of Torrance, California. A thin polyethylene plastic film is used to make them retain flexibility at temperatures as low as -112 degrees F, which is often encountered in the stratosphere."

In summary, the following accomplishments appear pertinent:

(a). three years of developmental work have achieved a light, relatively strong fabric having potential for high altitude balloon flight,

(b) a launching technique exhibiting very desirable operational characteristics has been realized,

(c) the MER-H-3 balloon vehicle for carrying a 3.5 pound scientific payload to 150,000 feet is considered to be off-the-shelf; larger payloads to 12 pounds can be carried to 140,000 feet, and

(d) there is strong growth potential holding promise for larger payloads to altitudes on the order of 150,000 feet.